METHOD AND ARRANGEMENT FOR POWER CONTROL IN A RADIO
COMMUNICATION SYSTEM

Field of the Invention

This invention relates to communication systems and
particularly (though not exclusively) to Time Division
Duplex (TDD) operation in radio communication systems.

Background of the Invention

In the field of this invention it is known that power
management of Forward Access Channel (FACH) transport
channels may be employed in a Universal Mobile
Telecommunication System (UMTS) radio communication
system.

In a 3rd Generation Partnership Project (3GPP) radio
communication system, the FACH is a common transport
channel used for downlink transmissions. Data destined
for a number of User Equipment units (UEs) may be mapped
onto FACH(s). The FACHs are then multiplexed by the
physical layer, mapped onto Coded Composite Transport
Channels (CCTrCHs), and transmitted on Secondary Common
Control Physical Channel (S-CCPCH) physical channels. UEs
receive the S-CCPCH physical channels, extract the
FACH(s) and identify data that is intended for them.
Typically the data to be sent on the FACH(s) is
rescheduled every Transmission Time Interval (TTI) (where
TTI = 10, 20, 40 or 80 ms).

The concept of applying power management on the FACH is
known in the prior art. For example, in published US
patent application no. US 2002/0094833 A1 it is known
5   that the transmit power is regulated according to:
        UE measurements
            - received signal strength
            - SIR (Signal to Interference Ratio)
            - Error rates (Block Error Rate - BLER, Bit Error
10   Rate - BER)
        Current conditions in the cell
            - traffic volume
            - % max BTS (percentage of maximum Base
                Transmitter Station) power in use.
15   Service requirements of the UE.

In document "MBMS Power Usage" (available from the 3GPP
website at
www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_31/Docs/Zips/R2-
20   022110.zip) and document "Comparison of DSCH and FACH for
MBMS use"(available from the 3GPP website at
www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_31/Docs/Zips/R2-
022110.zip) power control of the FACH has also been
suggested in 3GPP for broadcast usage (MBMS, Multimedia
25   Broadcast Multicast Service). Here the suggestion is made
that if the network knows the geometry of the MBMS users
in the cell, the transmission power can be set just
enough to serve all users subscribing to the MBMS service
instead of blindly using the power to cover the whole
30   cell.

However, a disadvantage of these and similar prior art schemes is the difficulty of estimation of the power needs of individual UEs.

5   Furthermore, the required measurement and processing operations of the UEs result in increased complexity and increased communication of data over the air interface.

Also, a simple power control operation may not result in
10   optimal resource usage in a communication system. Thus, conventional systems may have reduced capacity.

Hence, an improved method and arrangement for power control in a radio communication system would be
15   advantageous and in particular a system wherein the abovementioned disadvantage(s) may be alleviated would be advantageous.

20   **Statement of Invention**

Accordingly, the Invention seeks to preferably mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination.
25
In accordance with a first aspect of the present invention there is provided a method for power control in a communication system employing a Downlink Shared Control Channel (DSCH) and a Forward Access Control
30   Channel (FACH), comprising:
applying power control on the Downlink Shared Control Channel; deriving power control information from the

power control on the Downlink Shared Control Channel; and
applying to the Forward Access Control Channel the
derived power control information from the power control
on the Downlink Shared Control Channel in order to
5   produce power control on the Forward Access Control
Channel.

In accordance with a second aspect of the present
invention there is provided an arrangement for power
10   control in a communication system employing a Downlink
Shared Control Channel (DSCH) and a Forward Access
Control Channel (FACH), the arrangement comprising: means
for applying power control on the Downlink Shared Control
Channel; means for deriving power control information
15   from the power control on the Downlink Shared Control
Channel; and means for applying to the Forward Access
Control Channel the derived power control information
from the power control on the Downlink Shared Control
Channel in order to produce power control on the Forward
20   Access Control Channel.

The power control produced on the Forward Access Control
Channel (FACH) may be produced directly by adjusting a
transmit power for the FACH or may for example be
25   produced indirectly by scheduling of data to be
communicated on the FACH in response to the derived power
control information from the power control on the
Downlink Shared Control Channel.

30   Specifically, the applying to the Forward Access Control
Channel the derived power control information from the
power control on the Downlink Shared Control Channel in

order to produce power control on the Forward Access
Control Channel may be by applying to the Forward Access
Control Channel the derived power control information
from the power control on the Downlink Shared Control

5   Channel in order to determine a power requirement for the
Forward Access Control Channel.

The power requirement may be used to set a parameter for
the transmission of the Forward Access Control Channel

10   such as a transmit power or a scheduling of data.

The communication system may for example be a 3rd
Generation Cellular Communication System and may in
particular be a 3GPP 3rd Generation Cellular Communication

15   System as defined in the Technical Specifications
standardized by 3GPP.
These and other aspects, features and advantages of the
invention will be apparent from and elucidated with
reference to the embodiment(s) described hereinafter.

20

Brief Description of the Drawing(s)

One method and arrangement for power control in a radio

25   communication system incorporating some embodiments of
the present invention will now be described, by way of
example only, with reference to the accompanying
drawing(s), in which:

30   FIG. 1 shows a block schematic diagram illustrating
a 3GPP radio communication system in which the
present invention may be used;

FIG. 2 shows a schematic diagram illustrating multiplexing of FACH transport channels onto a single CCTrCH;

FIG. 3 shows a schematic diagram illustrating use of four CCTrCHs of S-CCPCH type to carry four FACHs;

FIG. 4 shows a block schematic diagram illustrating an power control arrangement incorporating an embodiment of the present invention;

FIG. 5 shows a schematic diagram illustrating an arrangement of queued FACH traffic;

FIG. 6 shows a schematic diagram illustrating traffic queued by Transport Format Combination Set (TFCS) band and served one band at a time;

FIG. 7 shows a schematic diagram illustrating banding of UEs on the DSCH into different TFCSs; and

FIG. 8 shows a schematic diagram illustrating a FACH power cost scheme.

Description of Some Embodiments

The following preferred embodiment of the present invention will be described in the context of a UMTS Radio Access Network (UTRAN) system operating in TDD mode. Referring firstly to FIG. 1, a typical, standard

UMTS Radio Access Network (UTRAN) system 100 is
conveniently considered as comprising: a terminal/user
equipment domain 110; a UMTS Terrestrial Radio Access
Network domain 120; and a Core Network domain 130.

5

In the terminal/user equipment domain 110, terminal
equipment (TE) 112 is connected to mobile equipment (ME)
114 via the wired or wireless *R* interface. The ME 114 is
also connected to a user service identity module (USIM)

10   116; the ME 114 and the USIM 116 together are considered
as a user equipment (UE) 118. The UE 118 communicates
data with a Node B (base station) 122 in the radio access
network domain 120 via the wireless *Uu* interface. Within
the radio access network domain 120, the Node B 122

15   communicates with a radio network controller (RNC) 124
via the *Iub* interface. The RNC 124 communicates with other
RNC's (not shown) via the *Iur* interface. The Node B 122
and the RNC 124 together form the UTRAN 126. The RNC 124
communicates with a serving GPRS service node (SGSN) 132

20   in the core network domain 130 via the *Iu* interface.
Within the core network domain 130, the SGSN 132
communicates with a gateway GPRS support node (GGSN) 134
via the *Gn* interface; the SGSN 132 and the GGSN 134
communicate with a home location register (HLR) server

25   136 via the *Gr* interface and the *Gc* interface
respectively. The GGSN 134 communicates with public data
network 138 via the *Gi* interface.

Thus, the elements RNC 124, SGSN 132 and GGSN 134 are

30   conventionally provided as discrete and separate units
(on their own respective software/hardware platforms)

divided across the radio access network domain 120 and
the core network domain 130, as shown in FIG. 1.

5 The RNC 124 is the UTRAN element responsible for the
control and allocation of resources for numerous Node B's
122; typically 50 to 100 Node B's may be controlled by
one RNC. The RNC also provides reliable delivery of user
traffic over the air interfaces. RNC's communicate with
each other (via the *Iur* interface) to support handover and
10 macrodiversity.

The SGSN 132 is the UMTS Core Network element responsible
for Session Control and interface to the HLR. The SGSN
keeps track of the location of an individual UE and
15 performs security functions and access control. The SGSN
is a large centralised controller for many RNCs.

The GGSN 134 is the UMTS Core Network element responsible
for concentrating and tunnelling user data within the
20 core packet network to the ultimate destination (e.g.,
internet service provider – ISP).

Such a UTRAN system and its operation are described more
fully in the 3GPP technical specification documents
25 3GPP TS 25.401, 3GPP TS 23.060, and related documents,
available from the 3GPP website at **www.3gpp.org**, and need
not be described in more detail herein.

FIG. 2 illustrates one use of the FACH. Here two FACH
30 transport channels (FACH1, 210; FACH2, 220) are mapped to
the same CCTrCH, 230, that is carried on a number of S-
CCPCH physical channels. FACH1 carries either 0 or 1 user

plane transport block, whilst FACH 2 carries either 0, 1
or 2 blocks of signalling traffic. Either a user plane
block or 2 signalling blocks may be carried by the
CCTrCH.

FACH2 is shared amongst all UEs, even during the same
TTI. The UE, on receiving the S-CCPCH, identifies which
signalling blocks are directed to itself by the UE ID
field in the Medium Access Control (MAC) header (as
described in 3GPP technical specification document
25.321, available from the 3GPP website) for the case of
DCCH (Dedicated Control Channel) logical channel or by
inspection of the UE ID within the RRC (Radio Resource
Control) message for the case of CCCH (Common Control
Channel) and SHCCH (Shared Control Channel).

To accommodate the variable rate of the CCTrCH, the
number of physical codes is adjusted, and the Transport
Format Combination Indicator (TFCI) carried on the
physical channel is used to identify this choice (as
described in 3GPP technical specification document
25.221, available from the 3GPP website).

Since the FACH is a common channel, the physical channels
need to be transmitted with sufficient power such that
all UEs targeted are able to decode the content.
Typically the transmission has taken place at full power
so that even if a UE at the cell edge is targeted, it
would be able to decode the transmission (this is a worst
case assumption). However, this is potentially wasteful
of power if, for example, all the UEs targeted were to
lie near the cell centre. Clearly, by only transmitting

with sufficient power to satisfy the user with the
greatest path loss from the basestation, power could be
saved which may be exploited by other physical channels
(not S-CCPCH). Furthermore, there is the alternative of

5   scheduling more FACH blocks within the same (maximum)
power.

FIG. 3 shows an alternative approach to using the FACH.
Here four CCTrCHs (CCTrCH1, 310; CCTrCH2, 320; CCTrCH3,

10   330; CCTrCH4, 340), each of S-CCPCH type, are
established, each supporting a single FACH. During a
transmission a single FACH only carries traffic for a
single UE. The UEs within the cell are subdivided into
those that listen to CCTrCH1 only, those that listen to

15   CCTrCH2 only, etc.

In this arrangement, without knowledge of the power
requirements of different UEs the worst case must be
assumed, where each FACH is carrying data to a UE at the

20   extreme cell edge, and each CCTrCH consumes the
corresponding power.

It is apparent that gains in throughput (or reductions in
power consumption) are achievable if some form of power

25   control can be introduced, whether a single S-CCPCH
CCTrCH (as in FIG. 2) or many (as in FIG. 3) are
employed. Furthermore, a reduced resource usage and thus
increased capacity of the communication system as a whole
may be achieved.

30

As will be explained in greater detail below, an
important feature of some embodiments of the present

invention is the use of power control to a UE on the
downlink shared channel (DSCH) to determine the UEs power
requirement on the FACH. The power requirement may be
used for controlling any parameter or characteristic
5   associated with the FACH. In particular, the power
requirement may be used to provide power control directly
by setting a transmission power of the FACH or inderectly
by performing scheduling of data in response to the power
requirement.
10

Referring now to FIG. 4, a power control arrangement 400
for implementing an embodiment of the present invention
includes a module 410 for deriving DSCH power control
information, and a module 420 for receiving the DSCH-
15   derived power control information and for performing in
dependence thereon FACH power control. Whilst not
inapplicable for Frequency Division Duplex (FDD)
operation, this scheme is particularly well suited to TDD
operation. This is because in TDD the DSCH may be used in
20   the same UE state as the FACH (this is called 'Cell FACH
state') without the need to allocate dedicated resources
(as described in 3GPP technical specification document
25.331, available from the 3GPP website). In other words,
a UE can be served on the DSCH, power information can be
25   extracted using the DSCH power control mechanism, and
then the UE can be rapidly and easily served on the FACH,
exploiting the power information gleaned from the DSCH
operation. DSCH operation in Cell FACH state is not
possible for FDD in a UMTS communication system; the UE
30   must move to Cell DCH state where it is granted dedicated
resource, in which it may receive DSCH (and FACH too,

although this requires that the UE has the capability to
decode three CCTrCHs at the same time).

The power control information of the DSCH may e.g. be
5   obtained: directly from RNC power control entity (if RNC
based power control), or indirectly from Node B power
control entity (if TPC power control at the Node B). The
power control on the FACH may e.g. be obtained in
different ways including: via TFCS selection, scheduling
10   of FACHs (number of codes / data rate) using a power
management calculation based on the above, power cost
calculation using C/I difference method, use of fixed or
dynamically updated C/I values, or queueing and serving
of UEs with similar power requirements on the FACH at the
15   same time.

Referring now to FIG. 5, in a preferred embodiment of the
present invention the FACH blocks are queued in one of n
queues 510_1, $510_2...510_n$, according to the CCTrCH that the
20   targeted UE is listening to. Each CCTrCH may employ up to
k_i spreading factor 16 (SF16) codes. The code sets
allotted to each CCTrCH are disjoint; the total number of
codes over all CCTrCHs must be less than or equal to 16.

25   In some embodiments, power control may be produced for
the FACH by scheduling FACH data in response to power
requirements determined from the DSCH. For example, a
FACH scheduler may determine a power requirement of FACH
data and schedule data for transmission on the FACH until
30   the combined power requirement exceeds a specified limit.

As an example, pseudo code for the operation of a FACH
scheduler is given below. The key operation of the
example is the calculation of the power cost of a CCTrCH
when supporting a transport format combination (TFC). A
5   TFC represents a particular combination of FACH blocks on
the FACH transport channels of the CCTrCH. The power cost
is defined as the fraction of the maximum transmit power
of the basestation. To calculate the power cost, p, we
calculate the difference of:

10   • the wanted signal divided by the level of noise
+ interference (C/I) at the UE j if it were to be
served with the complete basestation power
$C/I_{max,j}$ (this is determined from the DSCH power
control to the UE), and

15   • the C/I required to support the TFC, C/I_{TFC}
where both quantities are measured in dB, i.e.:

$$p_{TFC,j} = 10^{(C/I_{max,j} - C/I_{TFC})/10}$$

It will be understood that, as used herein, the terms
20   'noise' and 'interference' are to be considered
synonymous, with each encompassing both noise and
interference, and that the term 'signal/interference'
encompasses 'signal/(noise + interference)'.

25   Since FACH blocks may be scheduled from more than one UE
onto the same CCTrCH, the power cost should be calculated
assuming the worst case of the UEs scheduled, i.e., the
UE with the smallest $C/I_{max,j}$.

Queue = start_queue   /* e.g. every run of the algorithm

                         we increment the start_queue by 1

                         (modulo n) */

    Do

        Do

            Take the next FACH transport block from

            'queue'

            Calculate TFC resulting from adding the

            block

            Calculate power cost for this CCTrCH

            carrying TFC

            Accept FACH block to schedule if

            cumulative power cost of all CCTrCHs <= 1

        While (cumulative power cost of all CCTrCHs <= 1 AND

        k_{queue} codes can take more blocks AND queue is not

        empty)

        Queue = (queue + 1)mod n   /* go to next queue */

    While (cumulative power cost of all CCTrCHs <= 1 AND NOT

    all queues addressed)

Note: if DSCH power control information is not available

for UE j, the scheduler should assume the user lies at the

cell edge, and use a $C/I_{max,j}$ value appropriate for such a

user, either preprogrammed within the scheduler or

updated in response to information obtained from DSCH

power control (the scheduler would maintain the minimum

value of $C/I_{max,j}$ of all UEs served).

It should be noted that the C/I_{TFC} values may be fixed

(and preprogrammed into the scheduler) or updated

continuously according to measurements made by UEs.

Thus, in the example, an effective sheduling in response
to the power requirement determined from the DSCH is
achieved and thus the scheduler may control the
allocation of power resource to FACH data and e.g. to
different UEs.

In some embodiments, it may be advantageous to group UEs
such that UEs with similar power requirements share a
transmission. In this way the transmission power may be
suited for all (or most) of the UEs served.

Specifically, if the FACH CCTrCH is configured to support
a number of UEs in the same transmission, it is
advantageous to serve UEs with approximately the same
$C/I_{max,j}$ at the same time, since the worst-case $C/I_{max,j}$ is
assumed by the scheduler, as discussed above. The $C/I_{max,j}$
may for example be considered in view of the TFCS
(Transmit Format Combination Set) associated with
transmissions to the UE. One embodiment that exploits
this, for the case when there is a single FACH CCTrCH
($n=1$), is shown in FIG. 6. Here queue Q1 is subdivided
into 8 subqueues, denoted TFCS1 to TFCS8 (610_1,
$610_2...610_8$), and users are placed in the subqueue which
reflects their $C/I_{max,j}$ value. In this embodiment, these
correspond to the TFCS banding or grouping employed (see
below) such that UEs having similar power requirements
(e.g. falling within the same specified interval) are
allocated to the same subqueue. Different mechanisms for
serving the subqueues can be employed; FIG. 5 illustrates

a round-robin scheduler 620 that addresses a different
subqueue for each transmission.

In another embodiment of the invention, suppose the usage
5   of FACHs is as shown in FIG. 5; although, each CCTrCH is
restricted to use two codes (not four, because of
hardware limitations of the UE receiver). According to
the UEs power requirements on the DSCH, a UE is banded
(grouped) into different groups corresponding to a
10   suitable transmit format (TFCS). The system may use eight
different TFCS' from TFCS1 to TFCS8 and each TFCS may be
used as a power requirement. Thus, if the DSCH evaluation
indicates that a transmission to a UE matches the TFCS1
characteristics, the UE is allocated to the TFCS1 group,
15   if the DSCH evaluation indicates that a transmission to a
UE matches the TFCS2 characteristics, the UE is allocated
to the TFCS2 group, etc.

In the example, each UE is thus allocated into one TFCS,
20   from TFCS 1 to TFCS8 (710), plus "TFCS1 cell edge 1"
(720) and "TFCS1 cell edge 2" (730) bands, as shown in
FIG. 7. Essentially, the different TFCSs from 1 to 8
express the channel coding rate that may be employed with
a given transmit power to the UE, whilst attaining the
25   required signal to noise ratio. For example, UEs near the
cell centre experience low path loss and low
interference; they are placed in TFCS8 which has a code
rate close to unity (i.e., it has very little redundancy
to protect against noise). In contrast, with TFCS1, used
30   by UEs that are very close to the cell edge, the code
rate is approximately ⅓ - a lot more error protection is
required at the cell edge. UEs that experience a C/I

lower than the TFCS1 band are assigned to "TFCS1 cell
edge 1", or "TFCS1 cell edge 2". In the cell edge 1 band
a UE is given twice the power per code of a TFCS1 UE, and
in cell edge 2 the UE is given four times the power per

5   code. This is accomplished by limiting the number of
codes used in a timeslot (compared to TFCS1, half the
number of codes is used in cell edge 1 and a quarter of
the number of codes is used in cell edge 2). The channel
coding applied to the cell edge bands is identical to

10   TFCS1. Power control of the DSCH is examined by the RNC,
and decisions to switch a UE between TFCSs can then be
made (as in published patent publication WO 03/049320).
The TFCS in use is then used in determining the power
consumption on the FACH when serving this UE (see below

15   for details) - this is the 'power cost' introduced above.
Consequently, the number of FACHs that may be scheduled
is determined. For example, four UEs of band status from
1 to 8 may be served (on four FACHs, four S-CCPCH
CCTrCHs), but if a cell edge 2 UE is to be served then

20   only this UE may be served in this frame.

The power costs calculated are given in Table 1 below
(for the case where 1 FACH is mapped to 2 S-CCPCH codes).

TFCS	FACH power cost
TFCS1 cell edge 2	1.00
TFCS1 cell edge 1	0.50
TFCS1	0.25
TFCS2	0.25
TFCS3	0.25
TFCS4	0.25
TFCS5	0.25
TFCS6	0.25

| TFCS7 | 0.25 |
| TFCS8 | 0.25 |

Table 1

Thus for each group a standard FACH power cost is
allocated to each UE. The power cost is indicative of the
5   resource required to transmit a data block to the UE.

It should be noted that when transmitting to users from
any of the TFCS bands from 2 to 8, the same power cost as
TFCS1 is assumed. A more sophisticated algorithm that
10   adjusts the power cost across the complete TFCS range is
described below.

The FACH scheduler may thus control the power used and
allocated on the FACH by allocating FACH data in response
15   to the resource usage associated with the transmission of
the FACH data. For example, it may allocate FACH data
until the combined total FACH power cost exceeds a given
threshold.

20   Clearly the number of FACHs transmitted will now be
variable since it will depend on the DSCH TFCS which is
applied to the UEs to which the FACHs are to be sent. The
MAC will be required to provide this scheduling and
determine how many FACHs that can be let through to
25   Layer 1 and be consequently be transmitted.

It is likely that at any one time FACHs will be needed to
be transmitted to users which are on different DSCH TFCS
and therefore a scheme will be employed in the MAC based
30   on ratio of the total power available to the required
power for each FACH (called a FACH power cost), as

illustrated in FIG. 8, where four FACHs (810_1, 810_2, 810_3 and 810_4) are to be transmitted.

All messages sent on the Common Control Channel (CCCH),

5   or where the DSCH TFCS is not known, will have a FACH cost of 1.0.

An optional enhancement of some embodiments of the invention performs the power management under the

10 assumption that the *C/I* should be met but not exceeded for users in different bands. In this enhancement, Table 1 may be revised as follows:

TFCS	FACH power cost
TFCS1 cell edge 2	1.00
TFCS1 cell edge 1	0.50
TFCS1	0.25
TFCS2	0.19
TFCS3	0.13
TFCS4	0.09
TFCS5	0.07
TFCS6	0.05
TFCS7	0.03
TFCS8	0.01

Table 2

15 When using Table 2, the FACH power control must ensure that the available FACH CCTrCH code resource is not exceeded as FACH blocks are added to the schedule. With Table 1 this is not necessary, since the minimum power cost of 0.25 ensures that at most four FACHs (which

20 corresponds to 8 S-CCPCH codes) can be scheduled, which represents the code limitation of FACH CCTrCHs.

It will be understood that the present invention is not
limited to FACH power determination based upon the method
of TFCS selection described above. The FACH power may for
example be estimated provided that indication of the DSCH

5   power consumption is passed to the FACH scheduler,
located within the RNC.

Under typical conditions, the FACH and DSCH timeslots are
heavily loaded, and the C/I achievable in these slots is

10   approximately equal. In such circumstances, the FACH
power management scheme should work well. However, if the
network is lightly loaded, either in FACH or DSCH slots,
then the performance of the algorithm may be reduced.
This may be improved by the RNC determining whether to use

15   the power control algorithm based on DSCH operation (as
described above) or a conventional measurement based
calculation of the C/I achievable at the UE. In this way,
the DSCH based algorithm may only be used if the loading
on the DSCH in the neighbouring cells is high (the mean

20   code consumption over a set of neighbour cells on the
DSCH in the timeslots for which the UE has been granted
DSCH resource over a predefined time period exceeds a
threshold) and the immediate loading on the FACH is high
in the neighbouring cells (determined using a threshold

25   on the queued FACH traffic across the neighbour cells).

It will be understood that the method and arrangement for
power control in a radio communication system described
above provides a number of advantages including one or

30   more of the the following advantages:

- maximisation of throughput on FACH(s).

- exploitation of DSCH power control mitigates or
eliminates the need for additional measurements to be
taken by the UE.

5

- the resource requirement may be reduced and thus the
capacity of the communication system as a whole may be
increased.

10 It will be appreciated that the above description for
clarity has described embodiments of the invention with
reference to different functional units and processors.
However, it will be apparent that any suitable
distribution of functionality between different
15 functional units or processors may be used without
detracting from the invention. For example,
functionality illustrated to be performed by separate
processors or controllers may be performed by the same
processor or controllers. Hence, references to specific
20 functional units are only to be seen as references to
suitable means for providing the described functionality
rather than indicative of a strict logical or physical
structure or organization.

25 The invention can be implemented in any suitable form
including hardware, software, firmware or any combination
of these. The invention may optionally be implemented at
least partly as computer software running on one or more
data processors and/or digital signal processors. The
30 elements and components of an embodiment of the invention
may be physically, functionally and logically implemented
in any suitable way. Indeed the functionality may be

implemented in a single unit, in a plurality of units or
as part of other functional units. As such, the invention
may be implemented in a single unit or may be physically
and functionally distributed between different units and
5   processors.

Although the present invention has been described in
connection with some embodiments, it is not intended to
be limited to the specific form set forth herein. Rather,
10   the scope of the present invention is limited only by the
accompanying claims. Additionally, although a feature may
appear to be described in connection with particular
embodiments, one skilled in the art would recognize that
various features of the described embodiments may be
15   combined in accordance with the invention.   In the
claims, the term comprising does not exclude the presence
of other elements or steps.

Furthermore, although individually listed, a plurality of
20   means, elements or method steps may be implemented by
e.g. a single unit or processor. Additionally, although
individual features may be included in different claims,
these may possibly be advantageously combined, and the
inclusion in different claims does not imply that a
25   combination of features is not feasible and/or
advantageous. Also the inclusion of a feature in one
category of claims does not imply a limitation to this
category but rather indicates that the feature is equally
applicable to other claim categories as appropriate.
30   Furthermore, the order of features in the claims do not
imply any specific order in which the features must be
worked and in particular the order of individual steps in

a method claim does not imply that the steps must be performed in this order. Rather, the steps may be performed in any suitable order. In addition, singular references do not exclude a plurality. Thus references to "a", "an", "first", "second" etc do not preclude a plurality.